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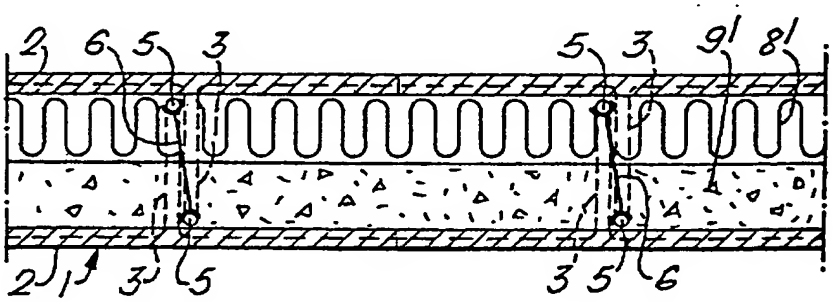

(57) Abstract

A construction system and a related cassette element, wherein thin concrete boards (2) provided with steel trusses (3, 5) and manufactured by means of the band rolling method of concrete or by means of any other concreting method are used, which boards remain parts of the final structure and at the same time form completed concrete faces for the structure. According to the invention, the thin concrete boards (2) are, either at the factory or on the construction site, mechanically connected by means of their truss structures, with the trusses (3, 5) facing each other, so as to make rigid, preferably prestressed cassette elements (1), wherein the thin concrete boards (2) with their reinforcements (4) and the truss steels (3, 5) operate jointly as a bend-proof cassette structure (1). By installing cassette elements (1) side by side vertically or horizontally, structures are formed in which the intermediate space between the thin concrete boards (2) is determined by the height of the steel trusses (3, 5). The intermediate space can be used as a space for positioning the heat insulation (8) and/or as a space for casting the frame concrete (9) cast in *situ* and/or as a space for equipment and conduits.

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Construction System Based on Thin Concrete Boards and Cassette Element for the Implementation of the System

The subject of the present invention is a construction system and a related cassette element, wherein thin concrete boards are used that have been produced by means of the method of band rolling of concrete or by means of any other concreting method and that are provided with steel trusses, said thin concrete boards remaining components of the ultimate structure while at the same time forming completed concrete faces for the structure.

The invention is concerned with a construction system wherein industrially prefabricated thin concrete boards that are provided with steel trusses, have a standard width and required length are assembled by placing two boards against each other and by mechanically locking them with each other by means of the truss steels so that the thin concrete boards and the truss steels are jointly operative and form a latticework beam resistant to bending stresses, the concrete boards constituting the flanges and the truss latticework constituting the web. In the cassettes formed in this way the intermediate space between the boards may be empty, it may contain channel and conduit structures, it may be partly or wholly filled with various heat insulations, filled with concrete cast in situ, light-aggregate concrete, or equivalent, partly or wholly. By placing cassettes side by side vertically or horizontally, it is possible to obtain wall, slab, or corresponding structures. The surface boards of the cassettes remain components of the ultimate structures, and their steel rigidifiers constitute the main part of the reinforcement of the ultimate structure.

The present construction methods that employ reinforced concrete are mainly based on two different techniques in the entire building or in its various structural parts. One of these is the normal technique

of casting in situ, wherein it is necessary to prepare firm shuttering constructions for the structures to be cast by using board, plywood, steel or plastics as the face of the shuttering. The latter materials are in use only in shuttering constructions that are used several times, such as large shutters, table, angle, and cup shutters. The reinforcement steels are installed and supported in the shuttering space to be concreted, whereupon the concreting takes place. After sufficient setting the shuttering is removed and the construction work on the skeleton is continued step after step. Later, during the interior finishing, the more or less successful concrete faces that remain visible are cleansed, patched, levelled, and painted or coated in the desired way.

Another common construction method is the prefabrication method, which is based on the use of various systems of prefabricated elements. In such cases the reinforced concrete skeleton is assembled out of factory-made prefabricated structural components, elements, by welding them together by means of steel achorages and by protecting the joint sections by means of after-casting. The elements are heavy to transport and to install. Element construction restricts the planning and causes limitations for the implementation of heating, ventilation and sanitation systems. The element joints additionally cause leakages of air, heat and noise in the final structures.

Attempts have also been made to use prefabrication and in-situ casting construction methods side by side in joint constructions of walls and slabs, wherein the steel-sheet or thin-concrete board shuttering structures at the same time form a component of the final structure. The use of prefabricated reinforced concrete boards in such production of reinforced concrete walls is described, e.g., in CH Patent No. 464,479 and DE Applications Nos. 2,236,463 and 2,310,348, in all of which shuttering boards that are supposed to remain parts of the final structure

are suggested to be used as the concreting shuttering of the wall, either as externally supported or as joined together by means of their reinforcement steels. The suggested solutions do not permit a binding together of concrete boards to make a bend-proof cassette construction, and under these circumstances their use is restricted to such structures only in which the rigidity of one reinforced steel board is sufficient or in which it must be supported by means of other structures. In the FI Patent Application No. 79,0862, on the other hand, the production of a cassette element "cast in situ" by means of a provisional intermediate filling material and intended for an individual bomb-shelter construction as well as a method for the construction of bomb shelters of class S1 based on the use of that cassette element are described. The production method also provides a cassette that has bending capacity, but owing to its massive nature its use is restricted to very thick and abundantly reinforced wall constructions only. In the prior-art methods described above, no cassette structure consisting of factory-made light board elements and being correspondingly resistant to bending stresses has been achieved.

Even though concrete and reinforced concrete are excellent construction materials, it has not been possible to resolve their use, e.g., in small houses and in agricultural buildings economically, because of which the use of concrete in such buildings is still scarce. The objective of economical construction activity is an industrial production of standard-dimensioned building components with a minimum amount of work and to produce the final structures out of these components without unnecessary working steps, as rapidly finished at low cost and with consideration being given to the requirements and hopes of the proprietor of the building regarding the use of the building. Each of the present construction methods has its limitations and deficiencies, and under

these circumstances we have not even nearly reached the optimum construction system, from the point of view of the proprietor of the building.

The construction system in accordance with the invention is mainly characterized in that the thin concrete boards are, either at the factory or on the construction site, mechanically connected by means of their truss structures, with the trusses facing each other, so as to make rigid, prefenably prestressed cassette elements, wherein the thin concrete boards with their reinforcements and the truss steels operate jointly as a bend-proof cassette structure, and that by installing cassette elements side by side vertically or horizontally structures are formed in which the intermediate space between the thin concrete boards, determined by the height of the steel trusses, is available as a space for positioning the heat insulation and/or as a space for frame concrete cast in situ and/or for ventilation, plumbing, electricity or other conduits.

Thus, according to the invention, industrially produced standard-width thin concrete boards provided with steel trusses are connected to each other by means of connecting means producing bending capacity so as to make cassette constructions. Out of thin concrete boards, a cassette construction resistant to bending stresses is formed according to two different principles. The construction can be formed either so that thin concrete boards are installed facing each other with the trusses interlocking each other and that they are locked by means of wide-flanged truss locks tensioned in the V-angles of the diagonal steels of the trusses, whereby the number and positioning of the locks is determined by the load resulting from the length and from the purpose of use of the cassette element, or by connecting the thin concrete boards to each other mechanically, in which case a U- or I-steel profile is fastened to one truss structure of a thin concrete board, which profile, as fitted to the edge

of the opposite board, fastens the boards to each other so that they stand bending, or by placing the trusses of thin concrete boards provided with different standard trusses so that the trusses interlock each other and by, by means of steel pins fastened to the trusses of one of the boards, locking the trusses into a joint standing shear forces. Cassettes made in this way are used in many different ways as base wall, ground-based wall, perimeter wall, partition wall, bottom floor, intermediate wall and top floor structure and as roof structure or as basic component of same. In this way a considerable improvement in the productivity of the construction industry and an expansion of the field of application of reinforced concrete structures can be achieved.

The invention comes out more closely from the following description and from the attached drawings, wherein

Figure 1 is an axonometrical view of the basic component of the construction system, a thin concrete board provided with steel trusses,

Figure 2 shows a section along line A-A in Fig. 1,

Figure 3 is a sectional view of a cassette element as viewed in the direction of the trusses while the intermediate space is filled with a heat insulation,

Figure 4 is a sectional view of a cassette element as viewed in the direction of the trusses while the intermediate space is filled with concrete cast,

Figure 5 is a sectional view of a cassette element as viewed in the direction of the trusses while the intermediate space is filled partly with heat insulation and partly with concrete cast,

Figure 6 is a sectional view of an alternative cassette element construction as viewed in the direction of the trusses,

Figure 7 is an enlarged sectional view along line C-C in Fig. 6,

Figure 8 is a sectional view along line B-B in Fig. 7,

Figure 9 shows an alternative solution for the structural embodiment shown in Fig. 3,

Figures 10 to 13 show examples of applications of use of a cassette element,

Figure 14 is a more detailed view of a truss lock,

Figure 15 shows an alternative embodiment for the truss lock shown in Fig. 14, and

Figure 16 is a sectional view of a cassette element in accordance with a preferred embodiment as viewed in the direction of the trusses.

In the following, the construction system in accordance with the invention will be illustrated step by step by describing the manufacture of the basic component of the system, the thin concrete board provided with steel trusses, the assembly of a cassette element, alternative inside structures of cassette elements, and finally preparation of structures out of cassette elements.

Manufacture of thin concrete board

Figure 1 shows the basic component of the construction system, the thin concrete board 2 provided with steel trusses 3,5. For the manufacture of this basic component, two different modes of manufacture are described. First, casting, in itself known, of a concrete slab on a stationary base by means of a casting machine, whereby both the reinforcement steel net 4 in the slab 2 and the truss structures 3,5 are placed on the base as longitudinally tensioned before casting. The casting machine ensures the position of the steels to the middle of the thickness of the slab 2. In the manufacture of the slab 2 in accordance with the invention, the steel trusses 3,5 are formed out of the same steel net as the reinforcement 4 of the slab part 2 by, in the way shown in Figure 2, bending the net in the transversal

direction into two folds as well as, by pulling, by producing a phase shift between the middle portion and the edge portions of the net, whereby the transverse division steels form the diagonal support irons 3 of the trusses and the longitudinal steels form the booms 5 of the trusses, or by welding the steel net straight into a configuration including the trusses. The height of the trusses 3,5 may be different in boards 2 manufactured for different objectives. The truss meshes can also be prepared in a known way as separate and be installed on the reinforcement net of the slab 2 before casting, even though this mode of reinforcement is not equally economical as that described above. Such a mesh truss is represented, e.g., by the German Filigran truss. Secondly, the manufacture of the basic component of the construction system is described as performed in accordance with the Finnish Patent No. 53,411, granted to the inventors, by means of a band rolling method of concrete, in which case the steel net folded so as to include the trusses, of the type described above, is fed along with the concrete mix into the rolling equipment and the result is a thin concrete board from one of whose faces the truss structures project, which truss structures have retained their shape owing to slits in the upper bands of the rolling equipment.

Owing to the little thickness of the concrete board 2 and in view of possible unprotected use of the truss components 3,5, the steel net must be protected by means of hot zinc-coating or in any other way or be made of stainless steel. As a cassette structure, the truss parts 3,5 may still be protected in a particular way.

The thin concrete board 2 may be surface-treated in a desired way, the concrete mix used may also be coloured concrete, in the mix it is possible to employ fibres in order to strengthen and to compact the concrete layer, and the board 2 can also be made waterproof by various treatments, e.g. with plastics.

The thin concrete board 2 may be lifted or otherwise handled by means of the steel trusses 3,5 as four-point lifting, whereby lateral bending of the trusses 3,5 should be avoided when the board is inclined, or lateral bending should be prevented by means of auxiliary supports.

Assembly of cassette elements in accordance with the invention

Figures 3 to 9 show solutions of principle of the manufacture of cassette elements 1 assembled out of basic components of the system described above. Thereby it is to be noticed that the basic boards 2 can be assembled into cassettes 1 in advance at the element factory, or the assembling can be performed at the construction site in the location and position required by the structure. Also, the step of filling of the interior of the cassette 1 depends on the purpose of use and the material of filling of the element.

Figure 3 shows a simple cassette 1, wherein the basic boards 2 are placed facing each other with the trusses 3,5 interlocking each other and wherein the boards are tensioned into their position by means of truss locks 6 of wide flanges installed in opposite V-angles of the diagonal steels 3 of the trusses 3,5. The compression stress of the locks 6 forms a constant prestressing in the diagonal steels 3 and is transferred by the wide flanges 7 to the thin concrete boards 2. The friction between the flanges 7 and the board 2, the exclusion of the shifting of the locks 6, owing to the truss diagonals 3, and the compression stress of the locks 6 create a statically indefinite condition which prevents shifting of the thin concrete boards 2 in relation to each other, and at the same time they form a bending capacity in the cassette structure 1. The number of the truss locks 6 is determined by the size of the cassette element 1 and by the bending stress determined by the purpose of use. The cassette element 1 may be filled with a heat-insulating

material 8, as is shown in Fig. 3, in which case the element 1 can be used as such, e.g., for wall and top floor constructions or alternatively, as is shown in Fig. 4, as space for casting frame concrete 9 cast in situ. To the inside face of one of the basic boards 2, as is shown in Fig. 5, it is possible to fasten a heat-insulating layer 8' or board, whereby the rest of the intermediate space in the cassette 1 can be used for structural concreting 9', or the cassette element 1 may be installed with a completely open interior space into the final object of use, where its intermediate space is utilized for ventilation, plumbing, electricity or other conduits. A favourable embodiment of this type is shown in the arrangement of Fig. 16, wherein a U-profile 17 is installed inside the cassette element 1 with the open side towards the thin concrete board 2 before the frame concrete 18 is cast, whereby the U-profile 17 together with the thin concrete board 2 forms a hollow space 14 in the element 1, which space can be used as ventilation, plumbing or electricity conduit or for other, corresponding purposes, whereby any necessary connections to the channel are obtained by drilling the desired holes through the thin concrete element.

Figure 9 shows a cassette element embodiment 1' in which a [- or I-steel profile 10 is fastened to one of the truss structures 3', 5' of each basic board 2'. Thereby the basic boards 2' are installed at the distance of the phase shift from each other, and the steel profile 10, as fitted to the edge of the opposite board 2', makes the cassette 1' bend-proof. In respect of the filling of the intermediate space, the procedure may be the same as described above. The basic boards 2' can also be installed as shown in Fig. 13 as overlapping each other, in which case an inclined roof construction can be laid out of the cassette elements without a separate plastic membrane insulation. In the cold season, the roof construction makes use of the heat-insulating capacity of snow, since the structure requires no ventilation.

Figure 6 shows the formation of a bend-proof cassette 1" out of thin concrete boards 2" provided with two different truss structures. The trusses 3", 5" are designed so that they can be placed as interlocking each other and locked by means of a pin construction 11 in the lateral direction. The pin construction 11 is capable of receiving all shear force resulting from bending and acting upon the diagonal steels 3". This mode of manufacture of a cassettes permits automatic production of cassettes, such an automatic process consisting of fitting together of the boards, injection of a polyurethane filling material, cutting, and possible after-coating of the boards.

Construction of structures in accordance with the invention out of cassette elements

Figures 10 to 13 show some typical structures constructed out of thin concrete board cassettes.

Figure 10 shows the construction of the outer wall of the basement of a small house facing the ground, with the cassette elements 1 installed vertically, whereby the footing structure can also be substituted for by prefabricated groove footings 12 placed on the ground at the joints of the elements 1. The cassette elements 1 are installed on these footing grooves by aligning and by wedging the element into its correct position. The horizontal steels required by the structure are installed into the intermediate space in the bottom part of the cassette elements 1, and the intermediate space of the entire wall is concreted at the same time, whereby the wall together with the footing becomes a completely monolithic structure. Compacted gravel around the footing elements and around the bottom ends of the cassette elements transfers the loads of the structure to the ground, and the heat-insulation layer ready in the intermediate space of the cassette guarantees a sufficient insulating capacity for the structure.

Figure 11 shows the use of a cassette element 1

in accordance with Fig. 3 as a wall or top floor structure with ready heat insulation.

Figure 12 shows a cassette element 1' in accordance with Fig. 9 as a wall or top floor structure with ready heat insulation.

Figure 13 shows a cassette element as laid overlapping each other in an inclined roof construction.

When the cassette elements as shown in Figures 3 to 5 and 9 are being assembled, it is possible to use a truss lock 6 in accordance with Fig. 14, wherein a steel device, provided with an articulated joint in the middle, as installed between the boom steels 5 of adjoining truss structures, tensions the boom steels 5 against the opposite concrete faces 2 while being at the same time locked at the articulated joint 13 and, owing to the widenings 7 at its ends, giving the cassette element 1 a lateral rigidity required in the case of transfers and transports. A truss lock 6', alternative to the truss lock 6 shown in Fig. 14, comes out from Fig. 15, wherein a three-component truss lock 6' to be used for the assembly of cassette elements is shown, in which lock the outer ends of threaded end components 15 constitute a widening 7' increasing the lateral rigidity of the cassette element, and by means of a tubular sleeve 16, provided with inside threading, the truss lock 6' can be tightened into its position at adjoining trusses between thin concrete boards.

It is characteristic of the construction system in accordance with the invention that, when the intermediate space between the thin concrete boards 2 in the cassettes 1 is used for concreting, the system combines the advantages of modern element technology at its best in respect of low weight and easy installation of the elements 1 as well as the advantages of conventional in-situ casting technique in respect of the dimensioning, density, and monolithic nature of the structures. Further advantages of the system are the circumstances that the

steels 3, 4, 5 industrially installed into the boards 2 constitute the main part of the reinforcement of the final structure, the possibilities of implementation of heating, ventilation and sanitation and electricity systems by using the interior spaces of the cassette elements 1 permits individual planning, no formwork has to be removed, and that the concrete faces that remain visible have a good standard of finish.

Likewise, the difficulties of bracing, noise insulation, sealing and jointing of the present element systems are omitted. When such a cassette element 1 is used in which the intermediate space is used exclusively for positioning the heat insulation 8, the construction system in accordance with the invention is a pure element construction system, and its advantages as compared with the concrete element systems in current use result from the quality of the surfaces, from the economy of the production, and from the low weight of the structures. The construction system in accordance with the invention with its numerous possibilities of use reduces the number of working hours necessary in construction as compared with what is required to-day. The overall construction time is reduced when the erection of the building frame becomes faster and when the interior finishing work is reduced. The requirement of energy during the construction stage is reduced while the construction time becomes shorter, because no openings for the removal of formwork are necessary in the outer mantle of the building, and therefore the expenses from the construction period are reduced. The construction system described above is well suitable for small houses, large buildings, low buildings, as well as for multi-storey buildings.

So far, it has not been possible to accomplish the construction system in accordance with the invention, because it has not been possible to manufacture the thin concrete boards 2 provided with steel trusses 3,5 and used as the basic components of the cassette elements 1

as of sufficiently low weight and of high quality. A revolution proper in the manufacture of thin concrete boards 2 for economical production of a high-quality, dense and dimensionally precise product was caused by the invention covering the band rolling of concrete. The present invention of the preparation of the steel trusses out of the same steel net with the reinforcement of the thin concrete board itself permits a highly economical production. The preparation of thin concrete board as a mechanical in-situ casting on stationary casting bases can also be developed by using casting equipment for long beams or hollow slabs so that they are suitable for the production of thin concrete boards provided with truss structures, whereby an economic result almost equalling the above and a rather good quality of the surfaces are also obtained.

WHAT IS CLAIMED IS:

1. A construction system wherein thin concrete boards (2) are used that have been produced by means of the method of band rolling of concrete or by means of any other concreting method and that are provided with steel trusses (3,5) projecting from one face of the board, said thin concrete boards remaining components of the ultimate structure while at the same time forming completed concrete faces for the structure, c h a r a c t e r i z e d in that the thin concrete boards (2) are, either at the factory or on the construction site, mechanically connected by means of their truss structures, with the trusses (3,5) facing each other, so as to make rigid, preferably prestressed cassette elements (1), wherein the thin concrete boards (2) with their reinforcements (4) and the truss steels (3,5) operate jointly as a bend-proof cassette structure (1), and that by installing the cassette elements (1) side by side vertically or horizontally, structures are formed in which the intermediate space between the thin concrete boards (2), determined by the height of the steel trusses (3,5) is available as a space for positioning the heat insulation (8) and/or as a space for frame concrete (9) cast in situ and/or for ventilation, plumbing, electricity or other conduits.

2. A cassette element for the implementation of the construction system as claimed in claim 1, the cassette element (1) consisting of thin concrete boards (2), c h a r a c t e r i z e d in that the basic boards (2) are placed facing each other with the trusses (3,5) interlocking each other and the boards are locked into their position by means of truss locks (6) of wide flanges tensioned in opposite V-angles of the diagonal steels (3) of the trusses (3,5), or that the trusses (3", 5") of the boards (2") are locked by means of steel pins (11) fastened to the truss part (3", 5") of one of

the boards (2") thereby forming a joint resistant to shear forces, or that a [- or I-steel profile (10) is fastened to one truss structure (3', 5') of the basic board (2'), which profile, as fitted to the edge of the opposite board (2'), fastens the boards (2') to each other with bend-proof joint at the distance of a phase shift from each other.

3. A cassette element (1) as claimed in claim 2, wherein as the basic board has been used a thin concrete board (2) provided with steel trusses (3,5) and manufactured out of reinforced concrete by means of the band rolling method of concrete as a process product, c h a r a c t e r i z e d in that the steel reinforcement fed into the band rolling equipment in connection with the manufacture of the board (2) forms truss structures (3,5) of steel and of constant height in the final product, which truss structures function as lifting means of the board (2) in connection with transfers and liftings and as fastening means when the thin concrete boards (2) are in pairs connected together to make cassette elements (1).

4. A cassette element (1) as claimed in claim 2, wherein as the basic board has been used a thin concrete board (2) of reinforced concrete, provided with steel trusses (3,5) and cast by means of a casting machine on a base structure, c h a r a c t e r i z e d in that the steel mesh of the board (2) has been bent at two points so as to form folds in the lateral direction, whereby diagonal truss structures (3,5) have been formed out of these folds so that the edge portions of the mesh remaining inside the concrete board (2) have been pulled in relation to the middle portion, while the magnitude of this phase shift determines the height of the truss structure (3,5), or that the reinforcement mesh to be used is welded to the desired shape.

Fig.1.

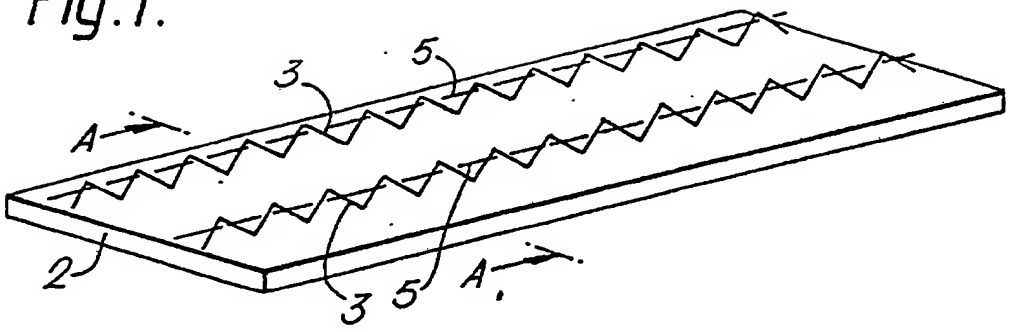


Fig.2.

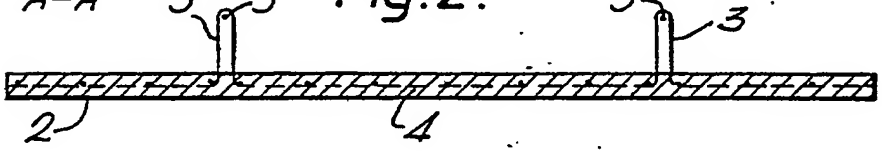


Fig.3.

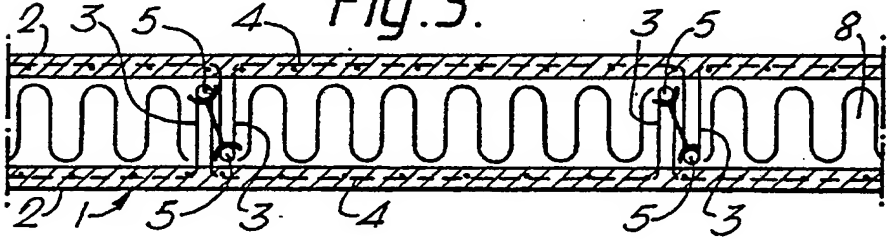


Fig.4.

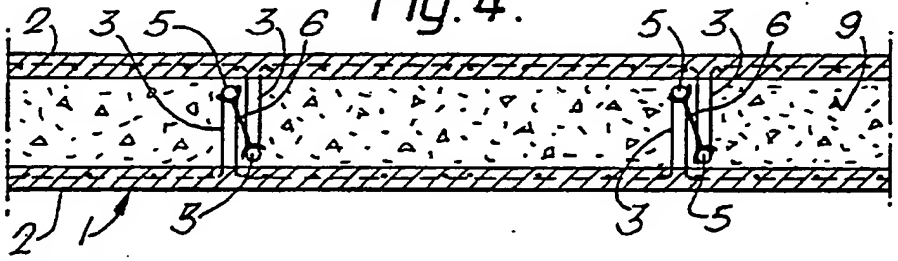


Fig.5.

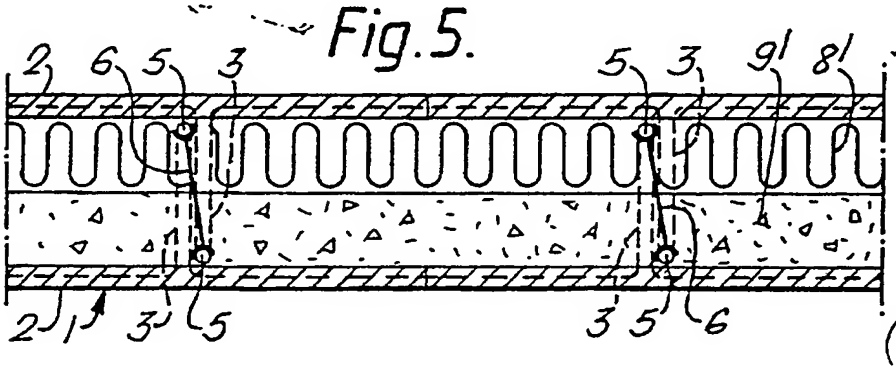


Fig.6.

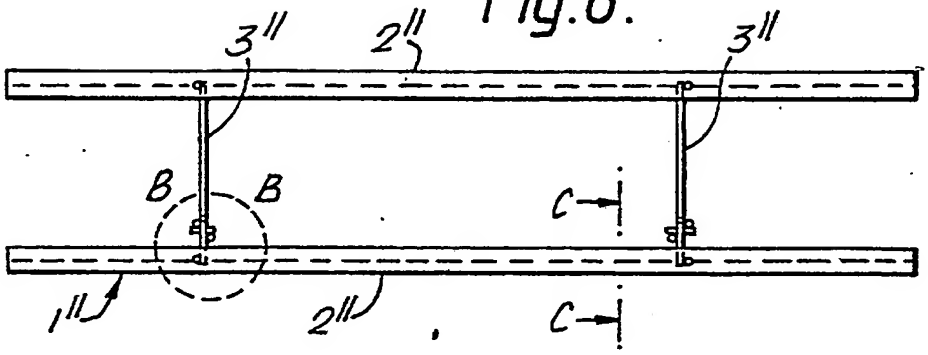


Fig.7.

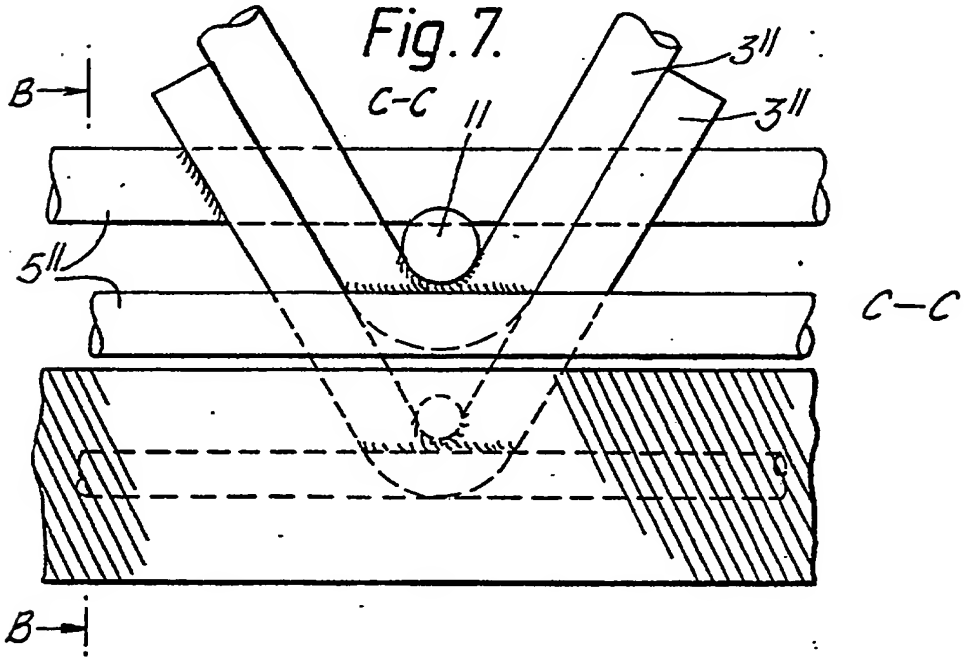


Fig.8.

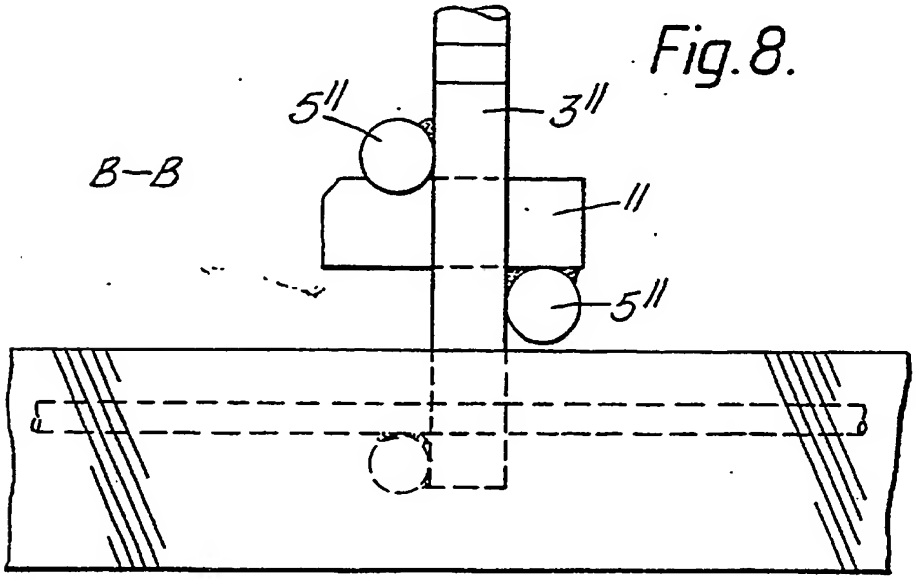


Fig. 9.

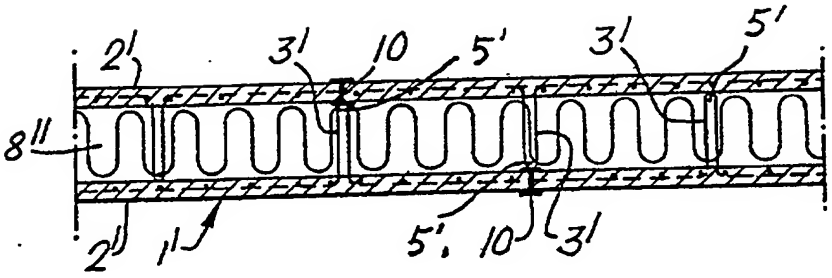


Fig. 10.

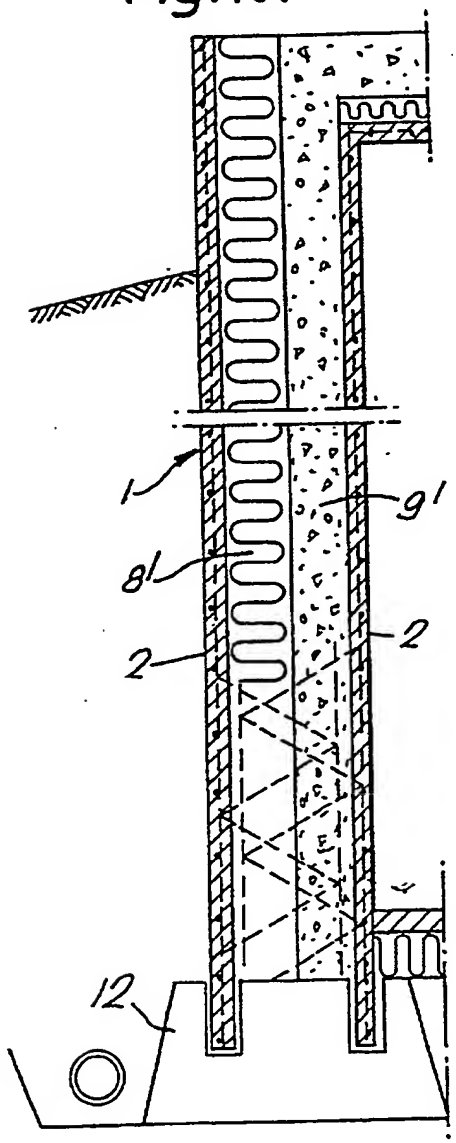
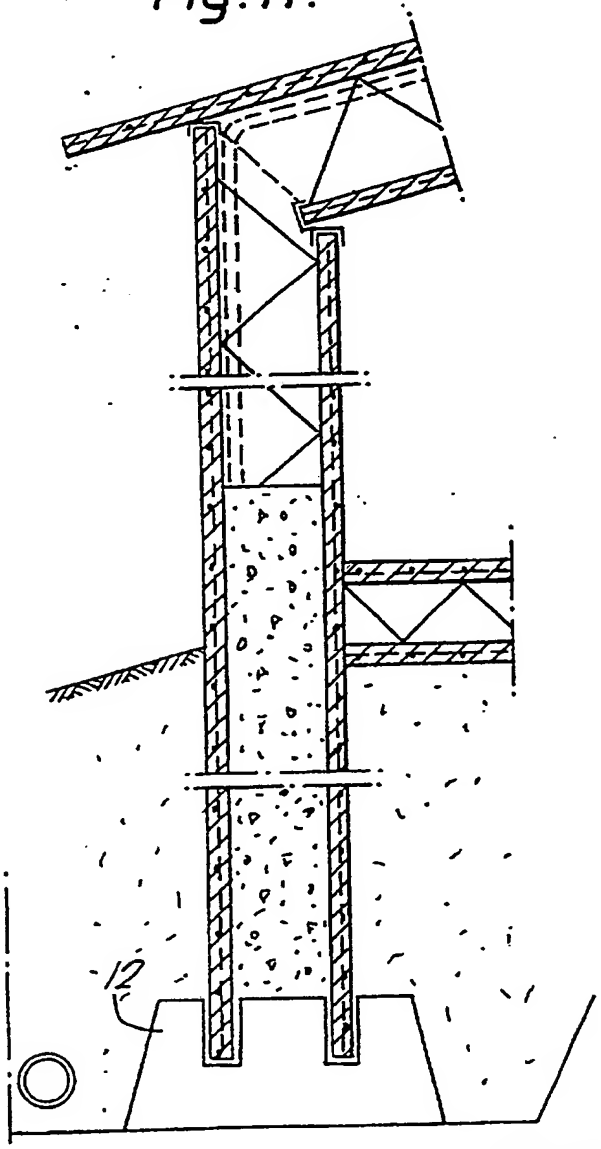


Fig. 11.



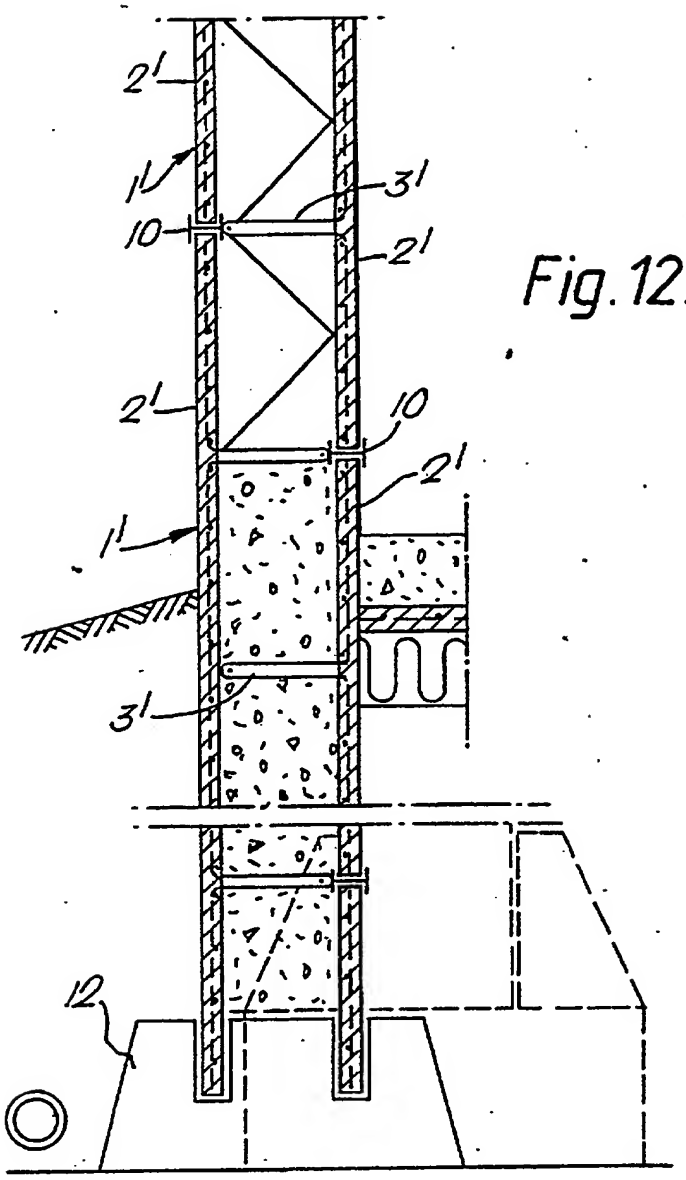
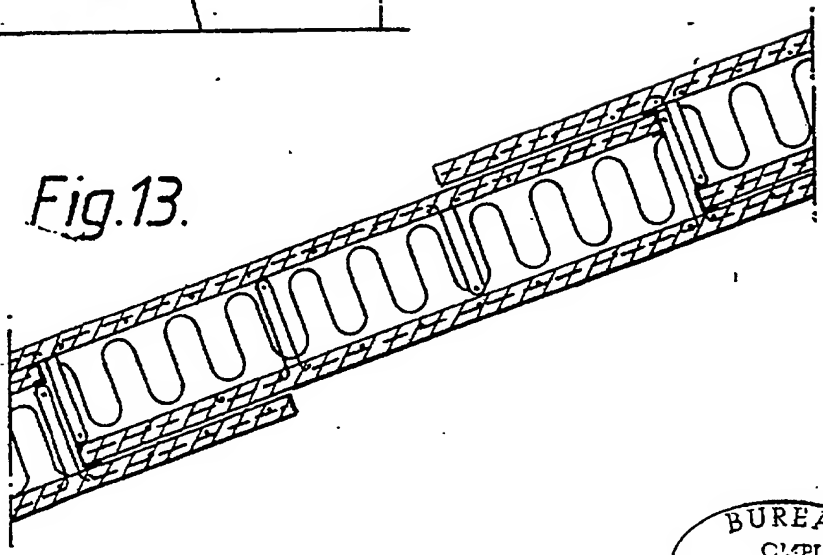


Fig. 12.

Fig. 13.



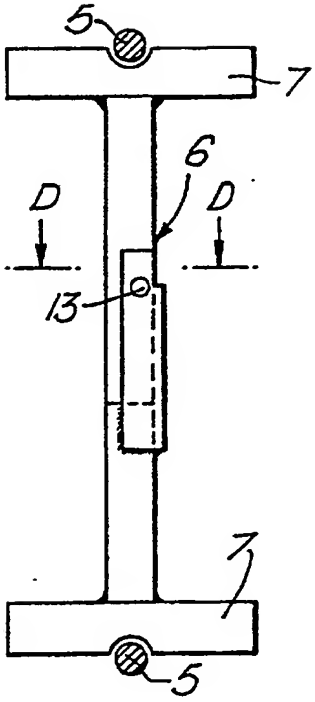
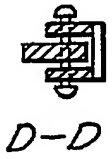


Fig.14.



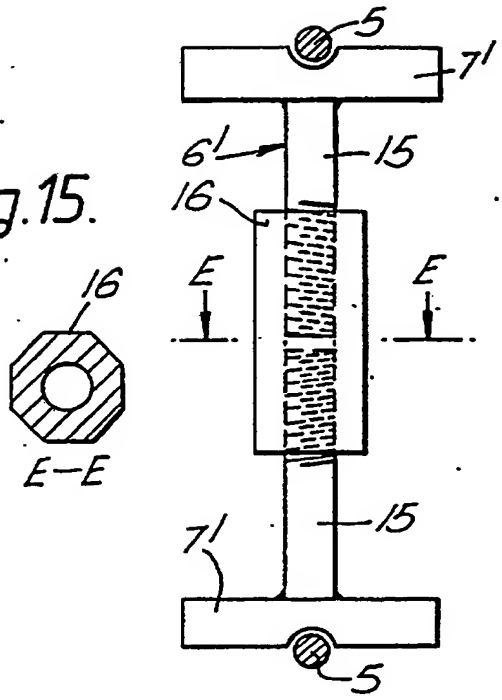
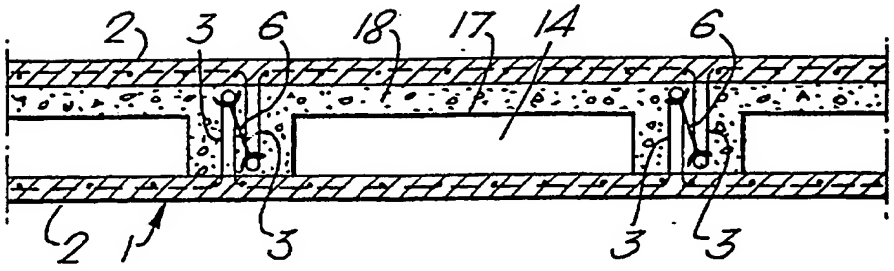


Fig.15.

Fig.16.



INTERNATIONAL SEARCH REPORT

International Application No PCT/FI81/00025

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC 5

E 04 B 1/04, 2/86 // E 04 B 5/10, 7/02

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
IPC 5 US Cl	E 04 B 1/02-06,2/54-68,84,86,5/00,02,10,16-29,7/00,02 52: 222;234,309,309.1-17,337,414-442,474,475,506-513, 761-781

Documentation Searched other than Minimum Documentation to the Extent that such Documents are included in the Fields Searched [4]

SE, NO, DK, FI classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
X	DE, A, 1 658 878 published 1970, November 26, G. Eubmann	1-4
X	DE, A, 1 708 946 published 1971, May 27, G. Hubmann	1-4
X	DE, A, 1 759 163 published 1971, February 25, G. Hubmann	1-4
X	CH, A, 464 479 published 1968, December 13, Bau-Stahlgewebe GmbH	1-4
L	CH, A, 508 109 published 1971, July 15, M. Zimmermann	1-4
A	DE, A, 2 242 202 published 1974, March 7, W. Wessel	1-4
A	DE, A, 2 256 463 published 1973, February 8, G.M.J. Williams	
A	DE, A, 2 510 348 published 1975, September 13, G.M.J. Williams	

* Special categories of cited documents: [15]

"A" document defining the general state of the art

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"P" document published prior to the international filing date but on or after the priority date claimed

"T" later document published on or after the international filing date or priority date and not in conflict with the application, but cited to understand the principle or theory underlying the invention

"X" document of particular relevance

IV. CERTIFICATION

Date of the Actual Completion of the International Search [3]	Date of Mailing of this International Search Report [3]
1981-06-02	1981 -06- 10
International Searching Authority [1]	Signature of Authorized Officer [20]